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April 1998

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Irene V. Laudeman
Ames Research Center, Moffett Field, California

Connie L. Brasil
San Jose State University, San Jose, California

Philippe Stassart
Sterling Software, Redwood Shores, California

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035-1000

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An Evaluation and Redesign of the Conflict Prediction and Trial Planning Planview Graphical User Interface

IRENE V. LAUDEMAN, CONNIE L. BRASIL,* AND PHILIPPE STASSART†

Ames Research Center

Summary

The Planview Graphical User Interface (PGUI) is the primary display of air traffic for the Conflict Prediction and Trial Planning function of the Center TRACON Automation System. The PGUI displays air traffic information that assists the user in making decisions related to conflict detection, conflict resolution, and traffic flow management. The intent of this document is to outline the human factors issues related to the design of the conflict prediction and trial planning portions of the PGUI, document all human factors related design changes made to the PGUI from December 1996 to September 1997, and outline future plans for the ongoing PGUI design.

Introduction

The Conflict Prediction and Trial Planning (CPTP) function has been implemented as a software process within the Center TRACON Automation System (CTAS). The CTAS system provides real-time information and advisories to air traffic controllers to help them improve the efficiency of the airspace system. CPTP uses the trajectory synthesis capability of CTAS to generate predicted route trajectories for the conflict search and trial planning processes (ref. 1).

The purpose of this memorandum is to address the design of CTAS Planview Graphical User Interface (PGUI) elements used in the CPTP functionality. The basic PGUI display included a scaleable representation of the airspace with jet routes, waypoints, sector boundaries, and aircraft symbols with their corresponding flight data blocks (FDBs). As the conflict prediction capability was instituted within the CTAS system, a conflict list displaying the aircraft pairs predicted to be in conflict and a limited graphical representation of conflict geometry was added to the PGUI.

The PGUI also displayed several large panels (accessed via functions keys) for setting the conflict probe parameters as well as all the other PGUI parameters. All of the setup panels and functions of the PGUI had been designed as the sole engineering prototype interface for the CTAS functionality. As with most engineering prototypes, it was not, nor should it have been, an interface appropriate for use by an end user. This document outlines the process by which the engineering CTAS PGUI was evolved into a PGUI more appropriate for use by an end user.

* San Jose State University, San Jose, California.
† Sterling Software, Redwood Shores, California.

Desired CPTP PGUI Capability

The human factors team conducted a preliminary familiarization and evaluation process during which a number of broad design issues were identified. The human factors concerns related to the CPTP PGUI design were as follows:

1. Color
   a. A color use philosophy did not exist.
   b. Color was not consistent.
   c. Color was used extensively and somewhat randomly, thus diluting the impact of its usage.
   d. Color use did not address the issue that controllers are not currently screened for color blindness.
   e. Perceptually problematic colors such as saturated reds and blues were widely used.
   f. Text and graphical information was generally presented in light shades against a black background.
   g. There was a hardware limitation of eight bit color and a software limitation of a three level color scheme with only three top level colors.
2. Display parameters
   a. No philosophy regarding how and when the PGUI should constrain the user regarding setup of system parameters.
   b. Large display setup differences were common across users, thus confounding some of the computer human interface (CHI) issues.

3. Global display
    a. Global commands for functions such as trend vectors, flight data blocks, range rings, and range/bearing required difficult to recall keyboard entries.
    b. Active aircraft inputs such as speed, altitude, and route changes were difficult to make.
    c. Track histories were not displayed in a format that used adequate update rates and symbology.
    d. Aircraft symbols were displayed using non-standard text symbology.
    e. Zoom and centering functions were very difficult to use, requiring excessive keyboard entries.
    f. General setup functionality was dispersed throughout a variety of function key panels.
    g. Help function was limited, outdated, and hard to understand.
4. Conflict detection graphics
    a. Minimal graphical display of conflict information made it difficult for a user to determine which aircraft were in conflict and what the conflict geometry was.
    b. Limited text information further complicated the conflict detection task.
5. Conflict resolution
    a. Provision of only one trajectory per aircraft resulted in an inability to display an active trajectory during trial planning, resulting in a loss of situation awareness.
    b. Complex and difficult to recall keyboard entries were required for active inputs for conflict resolution.
    c. No easily identifiable way (graphic or textual) to determine whether a conflict resolution has been identified.
    d. Mode awareness of active versus trial plan modes was nonexistent.
6. Text/Graphics presentation of information
    a. No reasoned approach to use of tabular versus graphical display of information.
    b. Initial display was heavily biased toward textual presentation of information.
    c. Graphical representation was unclear and hard to understand.
7. Occlusion of traffic display
    a. Large setup panels and pop-up windows occlude the traffic display at the start of operation.
    b. Conflict prediction list can occlude traffic display during system use.
8. PGUI element update rates
    a. Various display elements update at obviously different rates.
    b. No indication to the user of any of the update rate values.
9. PGUI CPTP user documentation
    a. User manual was minimal, outdated, and inaccurate.
    b. No training material.

PGUI Design Approach

It is relatively easy to provide design suggestions in an ideal world of limitless resources. The more challenging situation is the application of sound principles in an environment that demands constant compromise in order to meet resource constraints and the limitations of existing hardware and software architecture. Decisions of this sort were and are made on a daily basis during PGUI (and all CTAS related) design and implementation processes and required knowledge of system hardware and software as well as general human factors principles.

It is important to realize that in the development of an automated system, an engineering interface will evolve that meets the initial prototyping needs of the researchers (the PGUI as it existed in November 1996 was such an engineering interface). The use, and therefore the design, of an engineering interface is likely to be quite different from the kind of CHI that will be demanded by an end user.

There are principles of design that can be applied in the development of an end user CHI and it is important to realize that these principles might conflict with the personal preferences of individual researchers who are likely to have adapted to the engineering interface. It is also important to note that, while end user input is quite important in CHI design, end users are not qualified interface designers. An interface design will serve its purpose most effectively if it is designed using basic human performance and design principles as well as domain specific expert input and engineering expertise. The design process used in the implementation of the PGUI changes documented here was arrived at through an interdisciplinary and highly interactive and iterative process that included input from human factors, software development, and domain experts.

The following is a summary of the design changes that were made in response to the PGUI human factors evaluation. Each item is referenced to the human factors concerns listed in the Desired Capability section above. Following this section is a complete history of the changes made to the CPTP PGUI that will provide the reader with much more detailed information about each of the design changes noted here.

Color Redesign of PGUI

(1a–g) Development of a new color design for the PGUI was enabled by the implementation of a double buffer color infrastructure. The double buffer scheme provided access to 127 top level colors, which was enough color flexibility for the implementation of a total PGUI color redesign.

Conflict Detection Graphics Enhancement

(4a) The graphical conflict ambiguities were addressed by the addition of red conflict prediction lines that extended from the conflict aircraft to the point of first loss of separation.

Conflict Resolution Enhancement

(5a, b) A multitrajectory capability was designed and implemented by the engineering team that allowed the system to display both a trial plan trajectory that could be manipulated by the user and the active aircraft trajectory that displayed the actual position of the aircraft. Trial plan graphics were developed for altitude, speed, and vector changes using the new multiple trajectory capability. In addition to the multiple trajectory graphics, a panel was developed for use in trial planning inputs. This preliminary attempt at a "real" trial planning functionality allowed for situation awareness of the active trajectory while in trial planning mode and was the second large step in the evolution of the trial planning functionality.

As trial planning functionality was tested and evaluated by human factors, engineering, and end user teams, there was a strong consensus reached that the functionality had to evolve to a point and click interface that would remove the end user's hands from the keyboard. The point and click functionality was to be accessed through the relevant fields on the aircraft's flight data block. This removed the need for the trial planning panel and related keyboard inputs.

(5b) Simplification and linking of the capture waypoint and auxiliary waypoint functions were provided along with the simplification of the user input process for vectoring an aircraft. The purpose for these initial changes was to link functionality that was conceptually related and to take a first step in the evolution of a trial planning functionality.

(5c) There was no easy way for the user to determine whether a predicted conflict in an active trajectory had been resolved. The initial solution was to put an "R" for resolved in the time slot of the conflict prediction list. Trial plan trajectory conflict status was displayed with the addition of a Trial Conflicts Panel.

PGUI CPTP User Manual Updated

(9a) The CPTP functionality and PGUI setup parameters were incorporated into a CPTP User's Guide currently available in release 2.0.

PGUI CPTP Training Material Developed

(9b) A CPTP training packet was developed for use in training air traffic controllers at Ames Research Center and at air route traffic control center (ARTCC) facilities.

Design History

The intent of this section is to document all of the work conducted between December 1996 and September 1997 on the CPTP PGUI and to provide some insight into the intent behind each of the design changes.

December 1996

Conflict detection graphics enhancement (4a)– The initial PGUI had minimal graphical and textual indication of a detected conflict. Graphical information consisted of small red asterisks marking the point of initial loss of separation accompanied by a textual listing of the conflicting aircraft callsign above the asterisk. Consequently, it was difficult to determine which two aircraft were in conflict from either textual or graphical information. The textual presentation of conflict information was accomplished by the addition of the conflict aircraft callsign displayed in red in the fourth line of the data block as shown in figure 1. The fourth line was displayed by default as soon as the system identified a potential conflict. If a flight data block was not already displayed for a conflict aircraft, the data block was displayed automatically. The purpose for this change was to provide a redundant textual conflict cue in addition to the conflict list panel shown in figure 2.

The graphical conflict ambiguities were addressed by the addition of red conflict prediction lines that extended from the conflict aircraft to the point of first loss of separation as shown in figure 3. The red conflict lines were displayed when the user selected a conflict pair from the conflict list for further examination. The red lines provided cues that helped the users to identify the aircraft that were in conflict as well as providing conflict geometry information. Due to software constraints, the addition of the red conflict lines, which had to be drawn at a top level, revealed a significant design limitation in the number of colors available for use in the PGUI. Only three top colors had been specified to the PGUI and none of them were red. A lengthy software fix was implemented to respecify the top gray color to red as a CPTP specific PGUI run time option. This was an interim measure pending a redesign of the color infrastructure.

February 1997

Conflict resolution enhancement (5b)– The CTAS CPTP functionality was initially limited to producing only one trajectory per aircraft so that all trial resolutions were conducted using active trajectory inputs. The active inputs for speed and altitude were complex but manageable, as long as the user followed the right sequence. The user inputs required to examine various routing changes were disordered and quite unmanageable. For this reason, the redesign process began with a focus on the routing functionality needed for planning a direct waypoint or vectoring maneuver. A direct waypoint maneuver consists of sending an aircraft direct to a waypoint in the filed route of flight. A vector maneuver consists of giving an aircraft a heading off the filed route of flight and then having the aircraft rejoin the filed route of flight at either a waypoint in the filed route or an auxiliary waypoint that is created by the system.

The first change to the CPTP vector trial plan functionality included a simplification and linking of the capture waypoint and auxiliary waypoint functions used to vector aircraft. Additionally, the user input process for vectoring an aircraft was greatly simplified. The purpose for these initial changes was to link functionalities that were conceptually related and to take a first step in the evolution of a trial planning functionality.

The new functionality allowed the user to dwell on an aircraft symbol and type “Ctrl-a” to generate a flight plan route (green) and a profile selector (PFS) route (white) that was drawn from the aircraft to the default VOR (very high frequency omnidirectional radio range). The PFS route is the CTAS predicted route that is used for conflict prediction. The flight plan and PFS routes are shown in figure 4.

A white box appeared around the default capture waypoint VOR to facilitate identification of the default waypoint being used by the system (fig. 5). If the default waypoint was off screen, the box appeared at the edge of the screen with a text notation indicating that the default VOR was off screen. To change the default VOR, the user entered a new three letter identifier in a scratchpad.

An auxiliary waypoint (white asterisk) was created with a left mouse click on the PFS route. A center mouse click was used to drag the new auxiliary waypoint to desired position (fig. 6). The system was able to update the route quickly enough to provide a rubber band effect in the construction of a trial route. The user was able to exit the auxiliary waypoint mode with a dwell and left click on the aircraft.

March 1997

Conflict resolution enhancement (5a, b)– The CTAS CPTP system was initially limited to the construction of one PFS route per aircraft. This limitation resulted in an inability to display the active trajectory during trial planning. The loss of active trajectory situation awareness was not considered to be acceptable, and engineering redesign to provide dual trajectory capability was required.

A new multitrajectory capability was designed and implemented by the engineering team that allowed the system to display both a trial plan trajectory that could be manipulated by the user and the active aircraft trajectory that displayed the actual position of the aircraft. Trial plan graphics were developed for altitude, speed, and vector changes using the new multiple trajectory capability. In addition to the multiple trajectory graphics, a panel was developed for use in trial planning inputs. This preliminary attempt at a “real” trial planning functionality allowed for situation awareness of the active trajectory while in trial planning mode and was the second large step in the evolution of the functionality.

The user entered trial plan mode by dwelling on the aircraft to be trial planned and typing “shift-t.” The trial plan panel, shown in figure 7, would appear next to the aircraft. The trial plan panel allowed the user to trial plan and then implement a conflict resolution using vector, speed, and altitude changes.

A vector trial plan was accomplished by pulling up the Trial Planning panel and left clicking on the vector button of the Trial Planning panel to display the aircraft's red PFS and green flight plan route lines along with a yellow trial planning PFS route line. We again encountered color limitations and the yellow routes were constructed by dithering red and green.

To change the default VOR, the user had to left click in the text-entry field by VECTOR and type in the identifier of the desired waypoint, then left click on the VECTOR button as shown in figure 8.

An auxiliary waypoint was added by left clicking along the yellow PFS route (trial planning route). A center click and drag was used to position the auxiliary waypoint in the desired location. If the trial plan conflict list showed the conflict resolved with a new plan, it could be accepted with a left click on the trial plan panel Accept button. Upon acceptance, the yellow trial plan trajectory turned to white, denoting an active trajectory, and the old active trajectory was no longer displayed. To reject a trial plan, the user left clicked on the Reject button, which also exited trial plan mode. To try another trial plan, the user left clicked on the Clear button.

To initiate speed trial plan, the user left clicked on the speed button (+/– KIAS) of the trial planning panel and entered a trial plan speed value indicated as + or – from the current speed. The trial plan value was displayed in yellow on the fifth line of the trial plan aircraft's flight data block as shown in figure 9.

To perform an altitude trial plan, the user left clicked on Alt to activate the trial plan. The trial plan altitude value was entered in the trial planning panel and displayed in yellow on the fifth line of the trial plan aircraft's flight data block shown in figure 10.

Conflict resolution enhancement (5c)– Initially, there was no easy way for the user to determine whether a predicted conflict in an active trajectory had been resolved, as the user had to monitor the conflict list and note when separation criteria had been met. The initial solution was to put an "R" for resolved in the time slot of the conflict prediction list. The "R" proved to be a good preliminary fix, but something more salient was required for a better graphical representation of trial plan resolution status. For that reason, a Trial Conflicts list was designed as shown in figure 11 to allow the user easy access to resolution information.

PGUI CPTP user manual (9a)– The original PGUI user manual was found in the initial human factors evaluation to be outdated and inaccurate. An effort was begun to incorporate the CPTP functionality and PGUI setup parameters into a CPTP User's Guide. Release 1.0 of the Conflict Prediction and Trial Planning User's Guide was completed on March 31, 1997 (ref. 2).

April–May 1997

Conflict resolution enhancement (5a, b)– As trial planning functionality was tested and evaluated by human factors, engineering, and end user teams, there was a strong consensus reached that the functionality had to evolve to a point and click interface that would remove the end user's hands from the keyboard.

The point and click functionality was to be accessed through the relevant fields on the aircraft's flight data block. This removed the need for the trial planning panel and related keyboard inputs.

Access to the trial plan vector mode was made via a dwell and right click on the callsign located on the first line, first field of the aircraft's FDB. Altitude trial plans were accessed via altitude information on the second line, first field of the FDB. Speed trial plans were accessed via the speed information located on the third line, second field of the FDB. Additionally, flight plan information (not strictly speaking a trial plan function) was accessed via the aircraft's sector identifier number located in the first line, second field of the FDB.

All trial planning was accomplished with point and click graphics and pop-up menus which provided text, graphics, and color cues regarding the trial plan modes and status. Trial planning mode information was provided in yellow text on the fifth line of the FDB.

Upon accessing the Vector trial planning capability, a Vector menu pop-up would appear asking the user to select "change capture waypoint" option, "auxiliary waypoint" option, or reject (to exit). (This first menu pop-up proved to be an unnecessary extra step and was soon deleted.) The next menu pop-up (which soon became the first menu option box) enabled the user to select a capture waypoint. The system defaulted to the next VOR in the aircraft's flight plan and the user selected an alternative if desired. A yellow "V" appeared in the fifth line of the trial plan aircraft's FDB to indicate that the aircraft was in Vector trial plan mode as seen in figure 12.

The user was then able to determine whether sending the aircraft "direct to" that new VOR would resolve the predicted conflict. If the Trial Conflicts list showed that this maneuver would solve the problem, then the user could use the new heading and time advisories provided (in green) next to the aircraft symbol and issue them as a clearance to the aircraft. After issuing the clearance they could then accept, and hence activate, the change to the aircraft's route of flight by left clicking on the yellow "V."

If the "direct to" vector mode trial plan did not provide a resolution for the conflict, an auxiliary waypoint could be used to build a new route for the aircraft that would solve the conflict. After the default VOR has been chosen, left clicking anywhere on the red PFS route would create an auxiliary waypoint. The user could then middle click and drag the auxiliary waypoint until the PFS route changed to yellow, indicating a conflict free route as shown in figure 13. The controller could then issue the provided heading and time to turn back to the filed route of flight as a clearance to the aircraft.

When the altitude trial plan functionality was accessed, an altitude trial plan box appeared with the aircraft's current altitude highlighted as the default and all other possible altitudes listed above and below it as shown in figure 14. An altitude for trial planning was selected by left clicking on the desired altitude in the list. When a trial plan altitude was selected, the letters "TP" and the selected altitude appeared in yellow on the fifth line of the FDB as seen in figure 15.

When the speed trial planning functionality was accessed, a speed trial plan pop-up appeared with a list of speed modes (Ascent IAS, Descent IAS, Cruise IAS, Cruise MACH) as seen in figure 16. Left clicking on the desired speed mode produced a speed +/– IAS or MACH value box shown in figure 17. The trial plan +/– IAS or MACH speed (indicate +/– from current speed, i.e., +30 or –30) was selected by left clicking on the desired value. The current "active" indicated airspeed and the new trial plan input value +/– were displayed in yellow on the fifth line of the flight data block as shown in figure 18.

June 1997

Enhanced software infrastructure to provide increased color capability (1g)– Software and hardware limitations were experienced as the PGUI design requirements began to demand extensive color capability. The CTAS software graphics development team redesigned the system color infrastructure using a double buffering scheme that extended the system color capability to 127 colors and simultaneously eliminated the three level color scheme. Additionally, an interface was designed to provide researcher access to the color parameters for each of the PGUI elements. The ability to easily respecify the red, green, blue, and brightness values of each PGUI element is crucial for any color effort. The new color infrastructure provided the extended color capability needed to address elements 1a–f of the human factors evaluation.

Controller evaluation of the CPTP PGUI– An informal end user evaluation was conducted at this point in the PGUI design process. Three air traffic controllers representing FAA Headquarters, Boston ARTCC, and Fort Worth ARTCC were asked to use and evaluate the CPTP PGUI functionality during a two day period. The controllers also evaluated the training materials and user's guide that were being developed concurrently with the PGUI.

Design suggestions were sorted into three categories: changes to make immediately in preparation for field test, longer term redesign changes to existing functionality, and completely new functionality. The design suggestions are listed below along with whether they were immediate changes (I), redesign of current functionality (R), or completely new functions (N):

1. The default capture waypoint for arrivals should be the meter fix. The default capture waypoint should always be beyond the predicted conflict point. (I)
2. When vector trial plan is selected by clicking on the aircraft callsign, the initial pop-up window should be deleted from the design and the capture waypoint list should be displayed with the default capture waypoint highlighted. A reject button should be included at the top of the list. (R) and (I)
3. The conflict aircraft callsign for a trial plan, which is currently displayed on the forth line of the FDB, should be deleted. (R) (Note: restored later after further consideration.)
4. When a conflict is resolved and "R" appears in conflict prediction list, the conflict aircraft callsign in the fourth line of the FDB should be removed. (N) and (I)
5. The conflict probability color coding in the conflict list should be user selectable from the F9 Conflict Probe setup panel so that color coding may be turned off if desired. (N)
6. Infrastructure and PGUI panel should be colored to allow the following:
    a. Aircraft not owned or in conflict should have a low conspicuity relative to conflict aircraft. (N)
    b. Aircraft not owned or in conflict should have a limited data block (altitude only). (N)
    c. New aircraft symbols that show direction should be incorporated. (N)
    d. Red, yellow, and green colors should be reserved for conflict status. (R)

e. Route lines for trial plan should be displayed as a thick white line. (R)

f. Flight plan route should be displayed in gray. (R)

e. Conflict aircraft and corresponding FDBs should have a conspicuous color relative to nonconflict aircraft. (N)

7. Access should be provided to conflict graphic display through line 4 of data block consistent with the rest of the point and click functionality. (N)

8. Global trial plan should be clear (clear whole screen of all trial plans via keyboard input). (N)

9. Capability to dwell and click on all PGUI elements that are not part of trial plan function should be turned off when in trial planning mode. (R)

10. Flight plan route should not be displayed when a trial plan is activated. (R)

11. In line 1, field 2 of data block, sector number should be replaced with destination airport three letter identifier. (R) and (I)

July 1997

PGUI CPTP training material developed (9b)– Development of the Conflict Prediction and Trial Planning tool training packet to be used for training air traffic controllers at Ames and at the Denver ARTCC was completed.

National Air Traffic Control Research Institute (NARI) controller evaluation of the PGUI– A second evaluation of the CPTP PGUI was conducted with input provide by NARI controllers from New York ARTCC, Chicago ARTCC, Houston ARTCC, and Los Angeles ARTCC.

The controllers participated in one day of training on the use of the Conflict Prediction and Trial Planning tool followed by one day of simulations and evaluations. Design suggestions were again broken down into three categories: changes to make immediately in preparation for field testing of the CPTP functionality (I), longer term redesign changes to existing functionality (R), and completely new functionality (N). The PGUI design comments and suggestions were as follows:

1. It was difficult to transition between the use of the conflict list and the conflict graphics. Provide access to the conflict graphics via the conflict aircraft callsign in the fourth line of the FDB. (N) and (I)

2. It was difficult to determine whether an aircraft was in conflict with more than one other aircraft. The system needs to provide explicit information (text or graphics) about all aircraft that a single aircraft is in conflict with. (N)

3. There is too much clutter when all conflict aircraft data blocks are displayed. The system needs to provide a way to dim or suppress conflict data blocks. (N)

4. The flight plan amendment panels need to be redesigned into a single panel and should provide feedback to the user when flight plan amendments are made. (R)

5. Do not use “V” for vector in trial plan, it means VFR. (R) and (I)

6. Display all heading advisories in a three digit format (standard nomenclature). (R)

7. Place aircraft callsign on the route lines for ease of identification. (N)

8. Remove altitude information from the conflict list. It is not used and it is confusing. (R)

9. The accept function on trial plans needs to be easier and quicker to use. (R)

10. If an aircraft is “close” to the next waypoint in its route of flight, make the default capture waypoint the fix after rather than the next one. (I)

11. In the conflict list always round down to four miles if the separation is not five miles. (R) and (I)

12. Display conflict probe parameters (F9 setup panel information) on conflict prediction list for situation awareness purposes. (N)

August 1997

The design changes that were actually incorporated in preparation for the CPTP Field Test are listed below:

1. The default capture waypoint for arrival aircraft was specified as the meter fix.

2. The default capture waypoint was always specified beyond the point of conflict.

3. The initial pop-up window for vector trial planning was deleted from the design and the capture waypoint list displayed immediately with the default capture waypoint highlighted. A reject button was also included at the top of the list.

4. When a conflict was resolved and “R” appeared in the time to go field in the conflict prediction list, the conflict aircraft callsign in line four of the FDB was removed.

5. The conflict probability color coding in the conflict list was made user selectable from the F9 Conflict Probe setup panel.

6. The conflict graphic display was made accessible through point and click functionality via the fourth line of the FDB.

7. A global trial plan clear function was implemented using a “shift-t” input.

8. The sector number in line 1, field 2 of the FDB was replaced with the destination airport three letter identifier.

9. The “TP” text label was used for all trial plan modes.

10. All of the heading advisories provided by the system were displayed in full three digit standard nomenclature.

11. The time and distance components of the Conflict Prediction list were displayed rounded up to the five mile critical separation value as shown in figure 19.

PGUI CPTP user manual enhanced (9a, b)– CPTP User Manual Release 1.0 was updated with all the new software and functionality changes and Release 2.0 was released for printing.

There are ongoing updates and addenda to the current Release 2.0 of the Conflict Prediction and Trial Planning User’s Guide (ref. 3). There is also ongoing development of quick reference guides and training materials to serve as an adjunct to the user manual.

PGUI CPTP training material developed (9b)– A CPTP training packet was completed for use in training air traffic controllers at the Denver ARTCC who were scheduled to participate in the CPTP field study.

Proposed PGUI Design Changes

Color Redesign of PGUI (1a–g)

Development of a new color design for the PGUI was enabled by the implementation of the double buffer color infrastructure.

Some suggestions to be considered in a redesign of use of color on the PGUI are as follows:

1. A general philosophy of color use should be articulated prior to the beginning of the design process so that color use will be consistent throughout the display. A standard philosophy of color use in displays is that of color defined visual layers. The layers are defined by variation in color contrast, hue, saturation, number, and size of similarly colored features. If the color factors defining layers are manipulated correctly, the user will tend to group the appropriate objects in a layer. For air traffic control displays, a back layer might consist of a sector map and related static information displayed in low saturation colors of similar hue. A middle layer might consist of aircraft, data blocks, and related dynamic information in a more conspicuous color range than the back layer. A top layer might consist of alerting information in the most conspicuous color range.

2. Color should be used with care, as improper use of color can lead to eye strain, optical illusions, and cue confusion that can result in operator errors. A few basic principles are listed below:

   a. *Use of saturated blues and reds:* Shorter wavelengths of light (blue) are refracted more than longer wavelengths of light (red) as they enter the eye. As a result, reds and blues are brought into focus at different points within the structure of the eye. Constant refocusing is therefore necessary to resolve reds and blues, and this can lead to eye strain.

   b. *Use of contrasting colors:* Color contrast can result in figure ground illusions, particularly when using bright, highly saturated colors.

   c. *Color sensitivity:* The human eye is more sensitive to colors in the yellowish green portion of the spectrum than to reds and blues. As a result, saturated greens and yellows will appear to be brighter (hence more conspicuous) than saturated reds and blues. Blue has a particularly low subjective brightness.

   d. *Use of color with lettering:* Dark lettering on a light background is more legible than light lettering on a dark background.

   e. *Color discrimination:* Small changes in green and yellow are easier to detect than small changes of red or blue.

   f. *Color and peripheral vision:* Reds and greens are not resolved in peripheral vision as easily as blues and yellows.

   g. *Use of a variety of colors:* The fewer the colors used the greater the impact on the user.

   h. *Use of alerting colors:* Alerting colors should only be used for alerting functions.

Additional Functionality

There are additional proposed design changes related to new functionality for the CPTP PGUI as follows:

1. Incorporation of point and click functionality to provide easy access to PFS and flight plan routes for new aircraft entering the sector.
2. Provision of user request “autoprobe” to monitor aircraft and allow delivery of request as soon as an aircraft is in conflict free status.
3. Presentation of “hard” versus “soft” conflict status. Hard conflicts are those predicted where there is no clearance expected between an aircraft and the predicted point of conflict, and soft conflicts are those where there is a clearance expected that will result in a conflict.

Global Display Commands (3a, c, e)

There were design suggestions related to the implementation of a button bar for global commands (some of which are currently driven from the keyboard and some of which are additional functionality), including trend vectors, trial plan clear, flight data block quick deconflict, strip management, range and bearing, future situation display, zoom/center, latitude/longitude of cursor, and track histories.

Proposed Redesign of Selected Graphical Elements

(1f) Flight data blocks to have backfill and borders identifying alert and planning status.

(2a, 3b) Mouse inputs to be redesigned to use a standard of action method: left button for action (selection of specific menu items), middle button for move (drag), and right button for planning (access to menus).

(3c) Aircraft track histories to be consistent with radar histories in shape and update rate.

(3d) The aircraft symbol to be redesigned to a circle enclosing a triangular pointer giving aircraft direction. Flat track/free track information to be made available through the flight data block.

(3e) Zoom and centering functionality to be redesigned. The current zoom and centering functionality is quite crude and can easily result in disorientation of the display.

(5c) Trial plan routes to be drawn thicker.

(7a) Flight plan amendment panel to be redesigned to provide support for trial planning and active inputs and possibly extend to provide total paper strip replacement.

References

1. Erzberger, H.; Paielli, R.; Isaacson, D.; and Eshow, M.: Conflict Prediction and Resolution in the Presence of Prediction Error. 1st USA/Europe Air Traffic Management R&D Seminar, Saclay, France, 1997.
2. Conflict Prediction and Trial Planning Tool User’s Guide. Release 1.0 (March 31, 1997). NASA Ames Research Center, Moffett Field, CA.
3. Conflict Prediction and Trial Planning User’s Guide. Release 2.0 (August 29, 1997). NASA Ames Research Center, Moffett Field, CA.

Figure 1. Conflict aircraft callsign displayed in the fourth line of the flight data block.

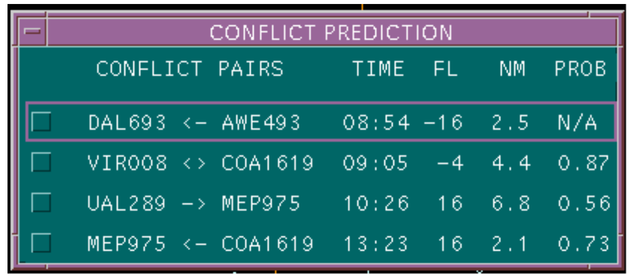

Figure 2. Conflict list panel.

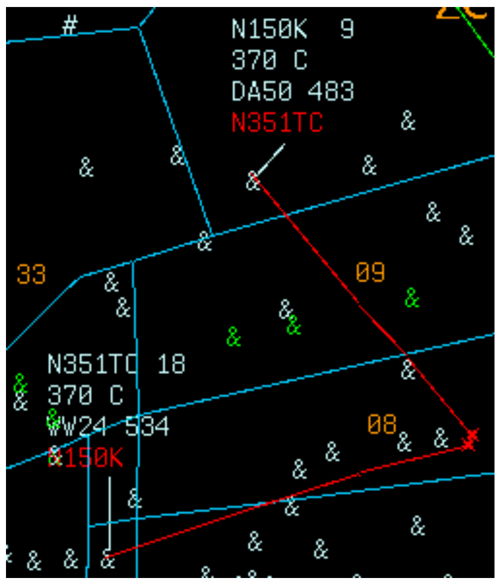

Figure 3. Conflict lines from aircraft to the point of first loss of separation.

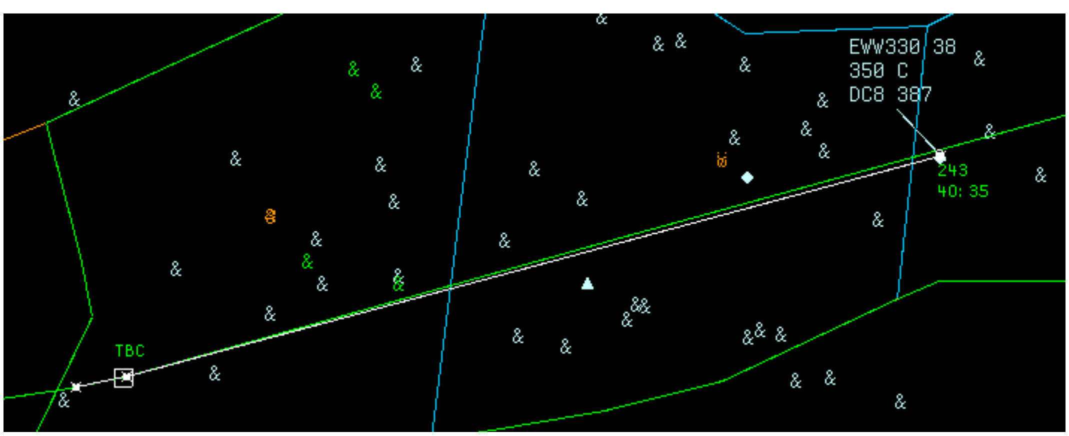

Figure 4. Flight plan route and PFS from a selected aircraft to the default VOR in the filed route of flight.

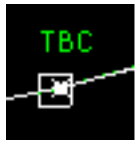

Figure 5. White box identifying the default waypoint being used by the CPTP.

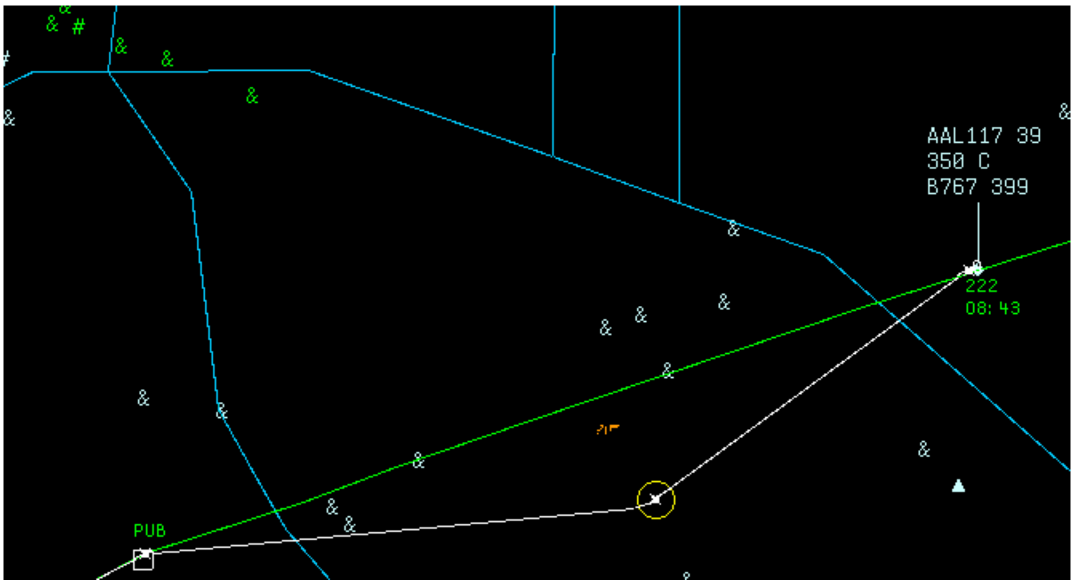

Figure 6. Construction of a trial route through an auxiliary waypoint.

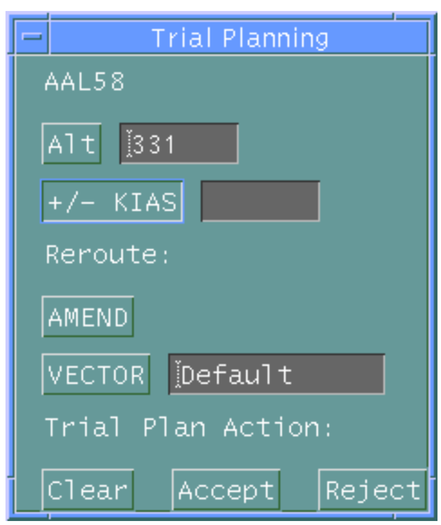

Figure 7. Trial planning panel for user inputs to trial planning functionality.

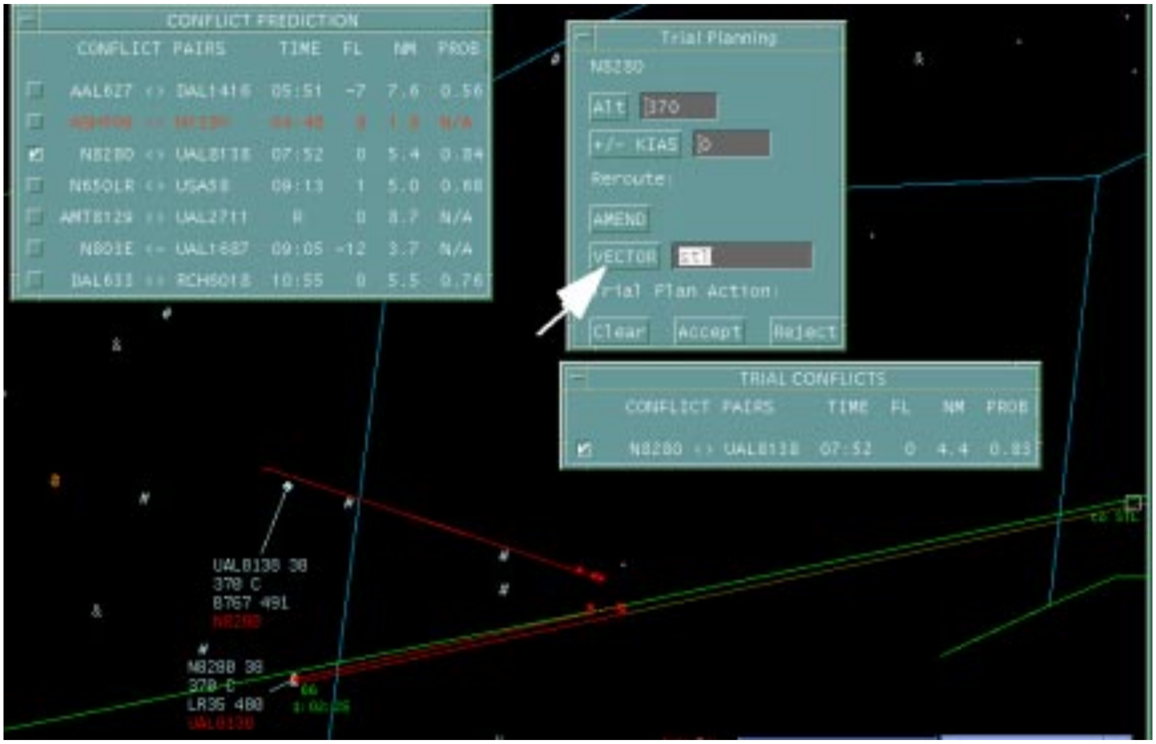

Figure 8. Vector trial planning using the trial planning panel for user inputs.

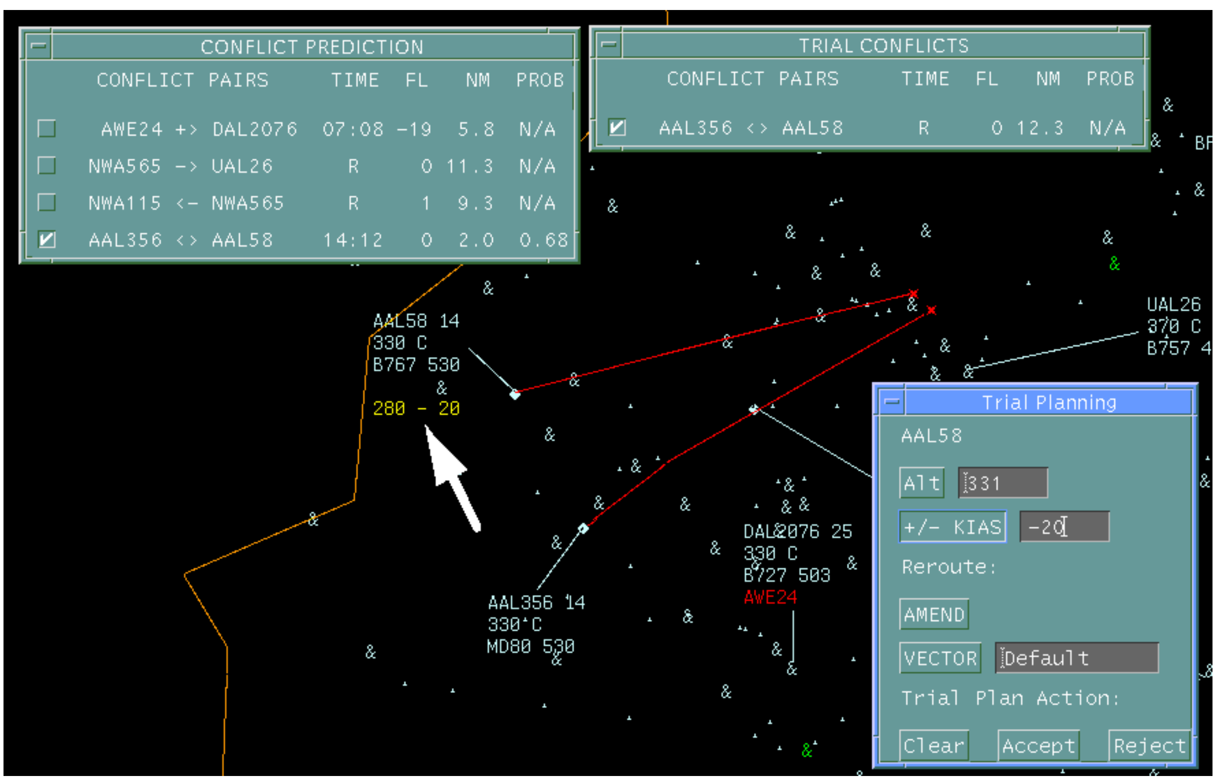

Figure 9. Trial planning of a conflict resolution using a change in speed of an aircraft.

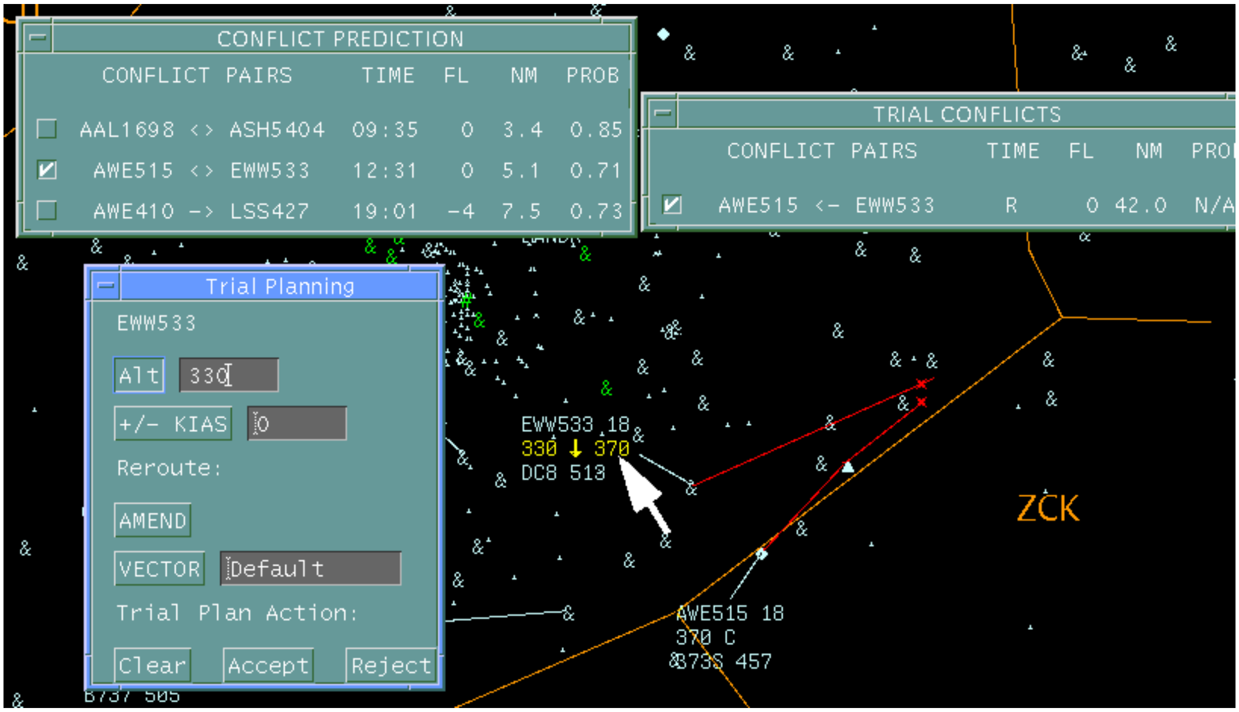

Figure 10. Trial planning of a conflict resolution using a change in altitude of an aircraft.

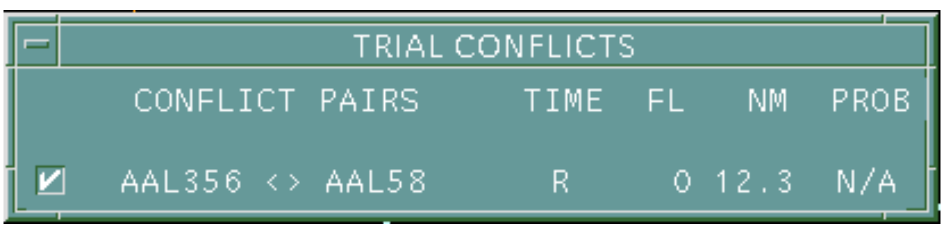

Figure 11. Conflict prediction list for trial planning trajectories.

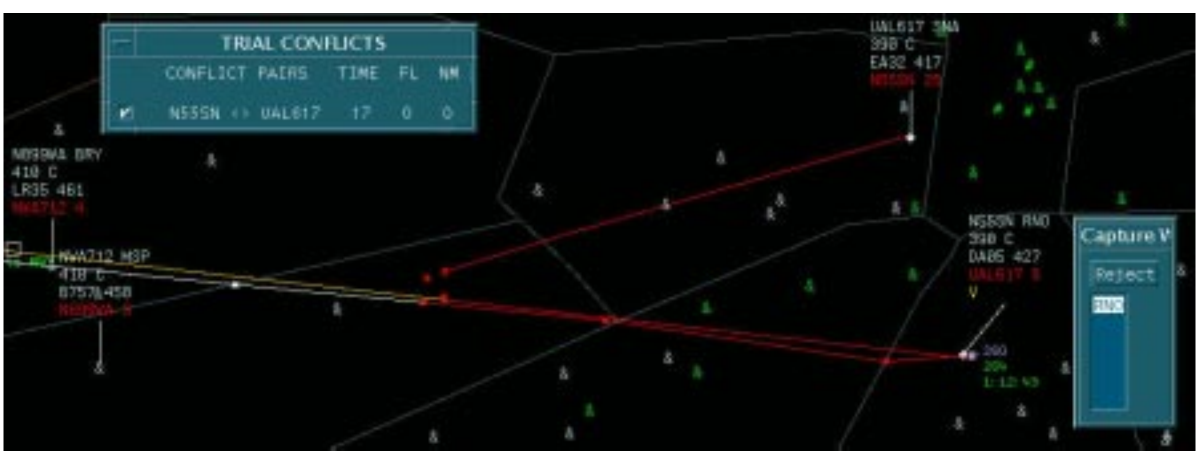

Figure 12. Aircraft in Vector trial plan mode.

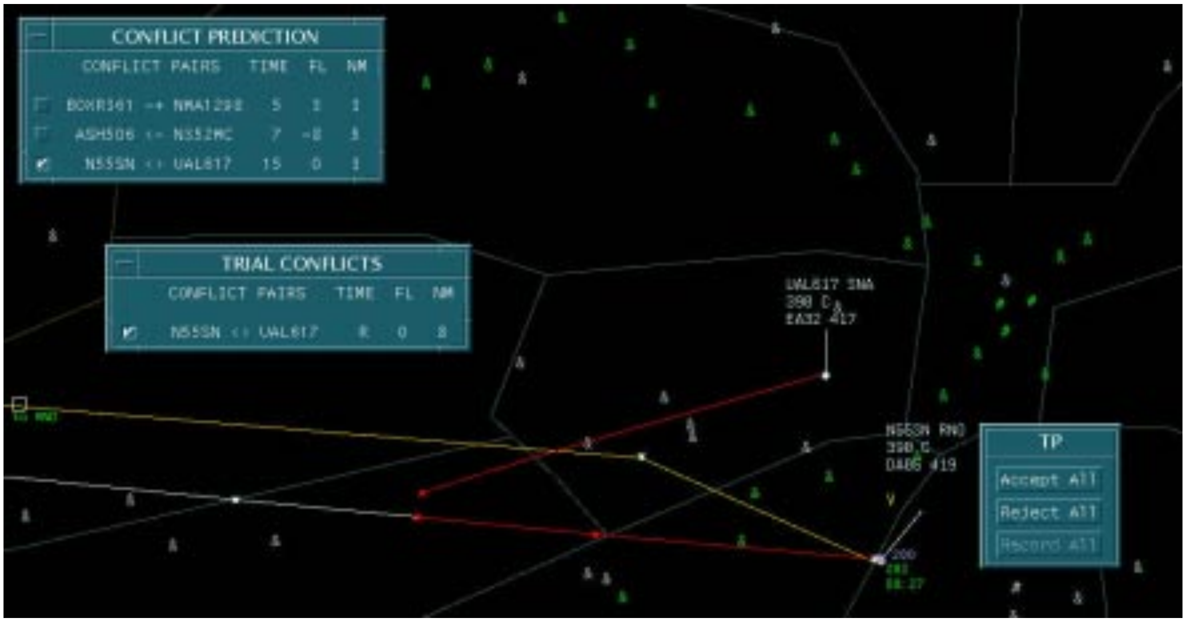

Figure 13. A conflict free trial plan route using an auxiliary waypoint.

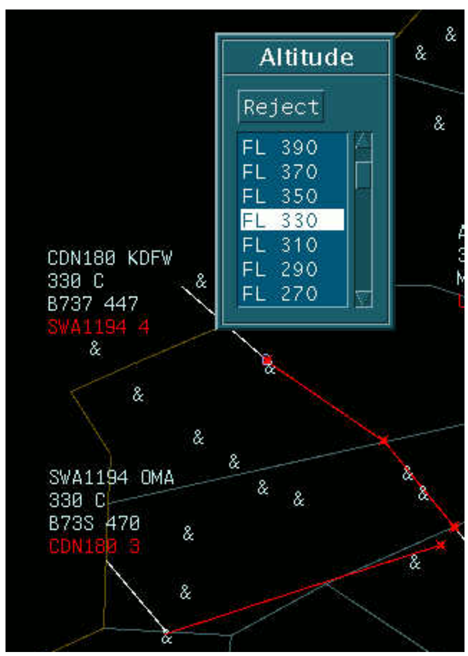

Figure 14. Aircraft in Altitude trial plan mode.

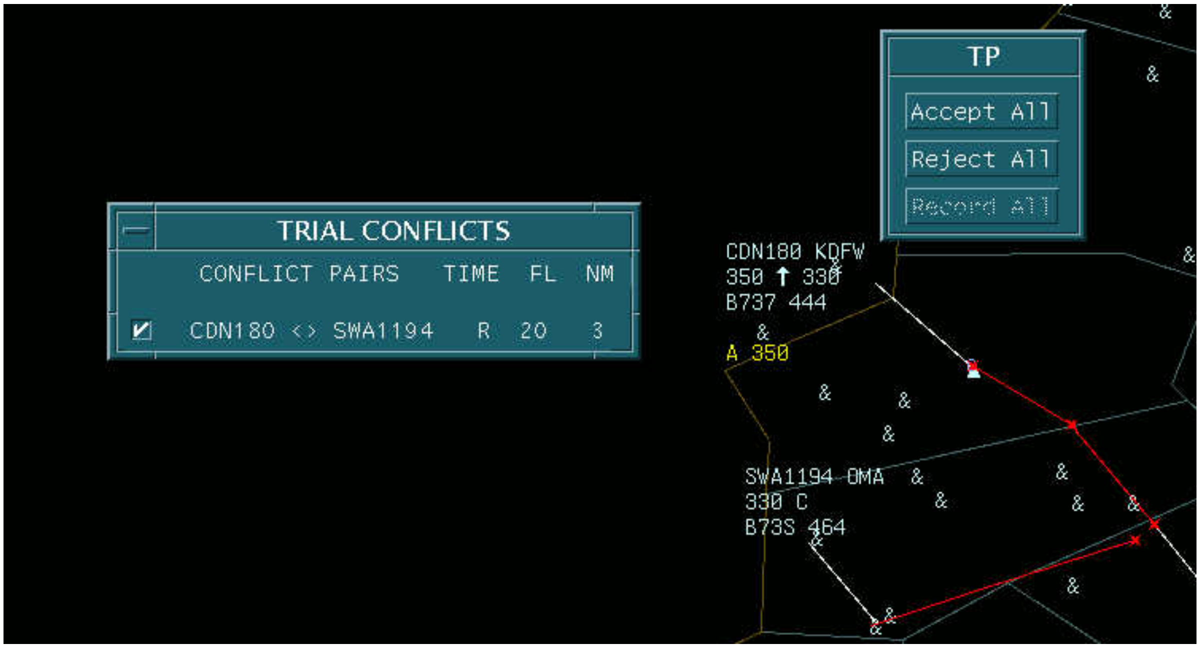

Figure 15. Display of a trial plan for changing an aircraft's altitude.

Figure 16. Trial plan speed modes.

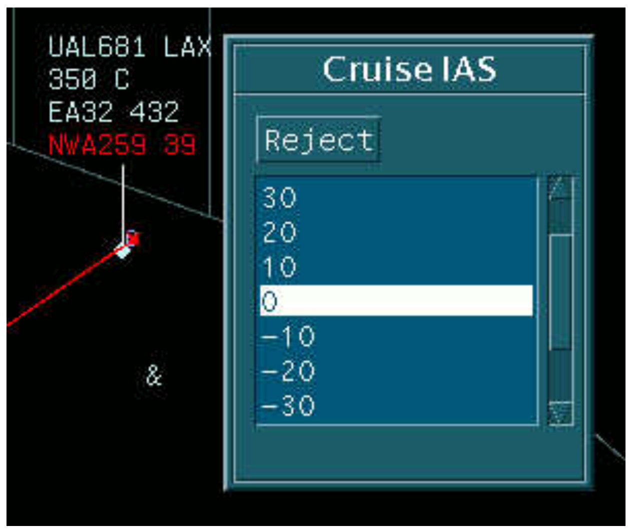

Figure 17. Trial plan speed values.

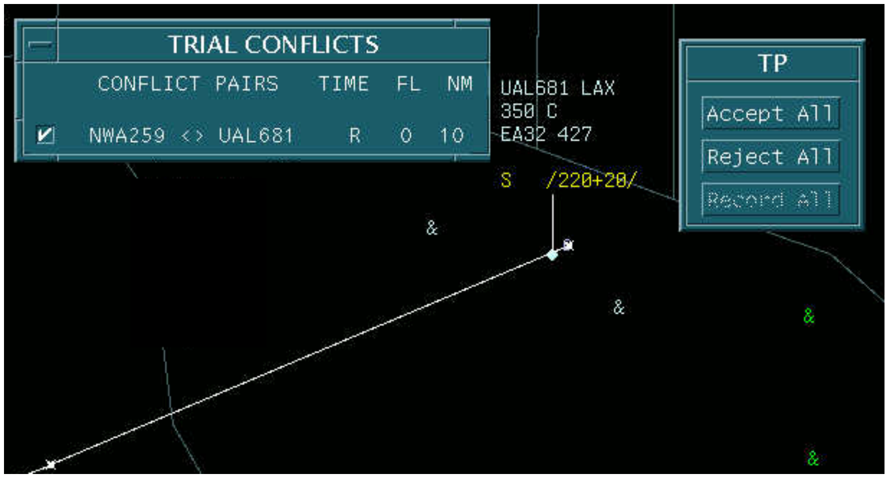

Figure 18. Display of a trial plan for changing an aircraft's speed.

Figure 19. Time and distance values displayed as whole number rounded up to the critical five mile value.

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Irene V. Laudeman, Connie L. Brasil,* and Philippe Stassart†

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Point of Contact: Irene V. Laudeman, Ames Research Center, MS 262-5, Moffett Field, CA 94035-1000
(650) 604-0018
*San Jose State University, San Jose, California. †Sterling Software, Redwood Shores, California.

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13. ABSTRACT ***(Maximum 200 words)***

The Planview Graphical User Interface (PGUI) is the primary display of air traffic for the Conflict Prediction and Trial Planning function of the Center TRACON Automation System. The PGUI displays air traffic information that assists the user in making decisions related to conflict detection, conflict resolution, and traffic flow management. The intent of this document is to outline the human factors issues related to the design of the conflict prediction and trial planning portions of the PGUI, document all human factors related design changes made to the PGUI from December 1996 to September 1997, and outline future plans for the ongoing PGUI design.

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